

# **Impacts due to APM Terminal Dredging and the Berthing of Ships at both the CIEE and APM sites**

by

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# Background

- APM Terminal dredging was not known at the time of original study
- VPA requested VIMS to analyze the long-term, far-field hydrodynamic impacts resulting from this dredging
- In addition, berthing of ships at both the CIEE and APM sites was evaluated

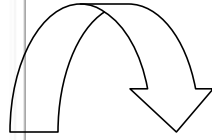
# Outline

- Review prior CIEE study and results
- Assess impacts of dredging at APM site
- Assess impacts of ship berthing at both sites
- Compare these impacts to those of the original expansion options
- Flushing evaluation (simulated dye release)

# Location of Study Area

Hampton  
Roads

*Atlantic Ocean*



Hampton Roads  
Proposed Third Crossing

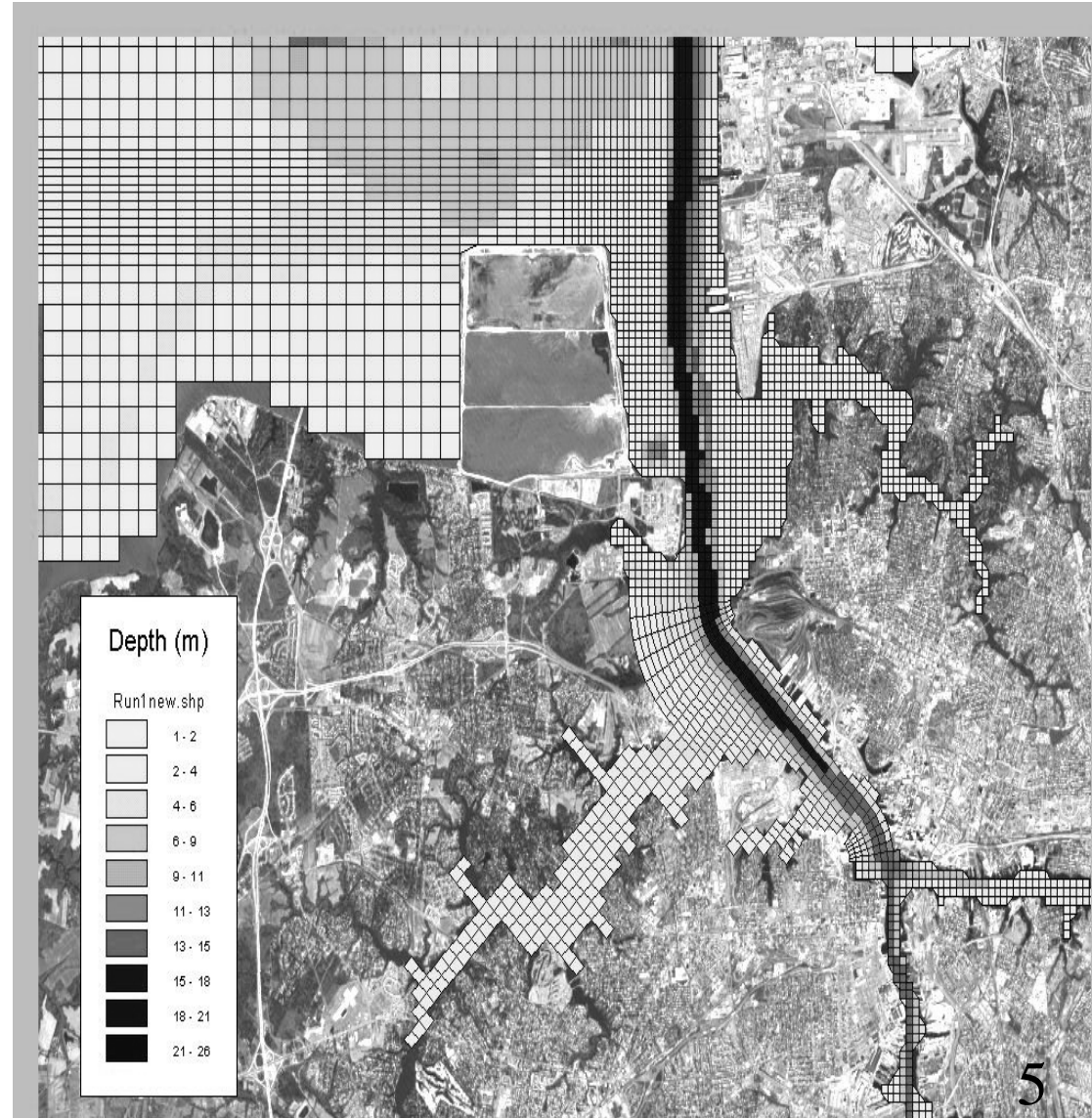
Norfolk

Craney Island



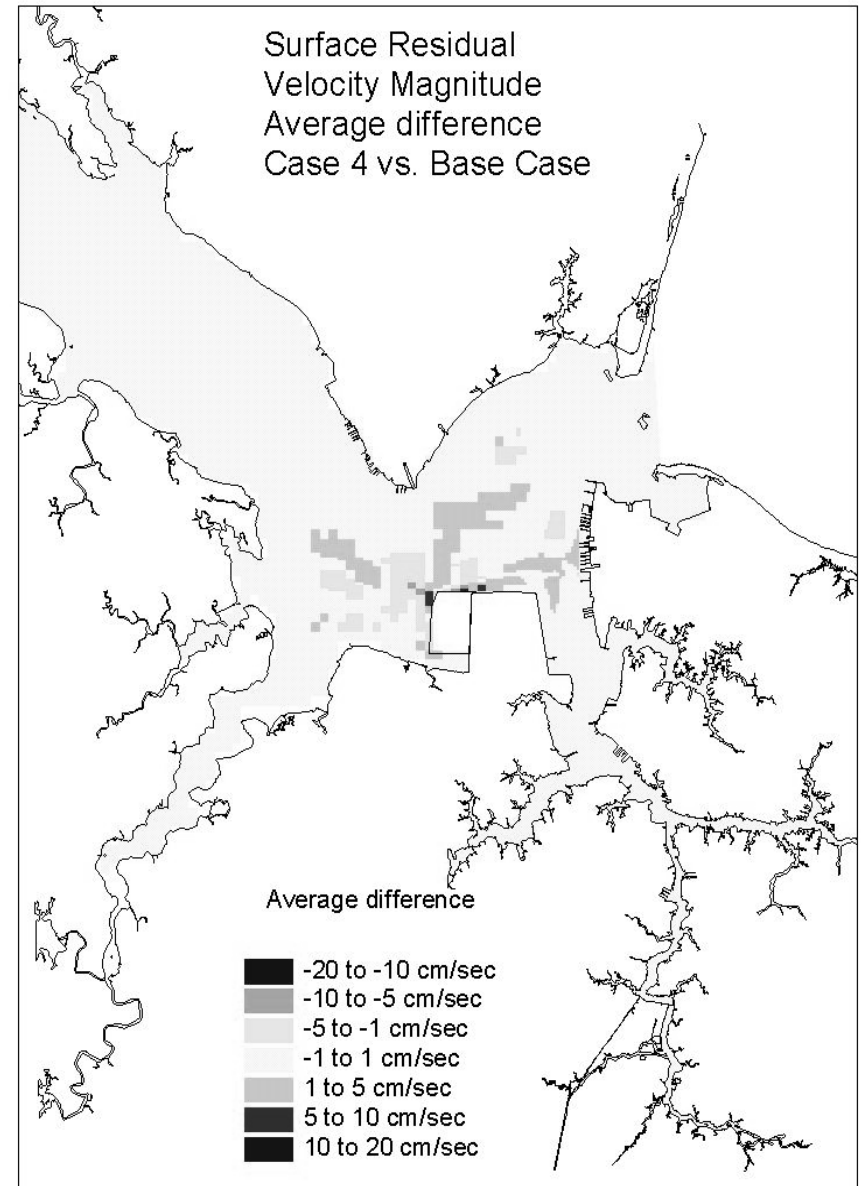
# VIMS HEM-3D Model

- Predicts real-time tide, velocity, salinity, and sedimentation potential
- Uses a variable grid dimension
- Incorporates man-made structures
- Performs with stability even under extreme conditions (e.g., variable discharge, high wind)



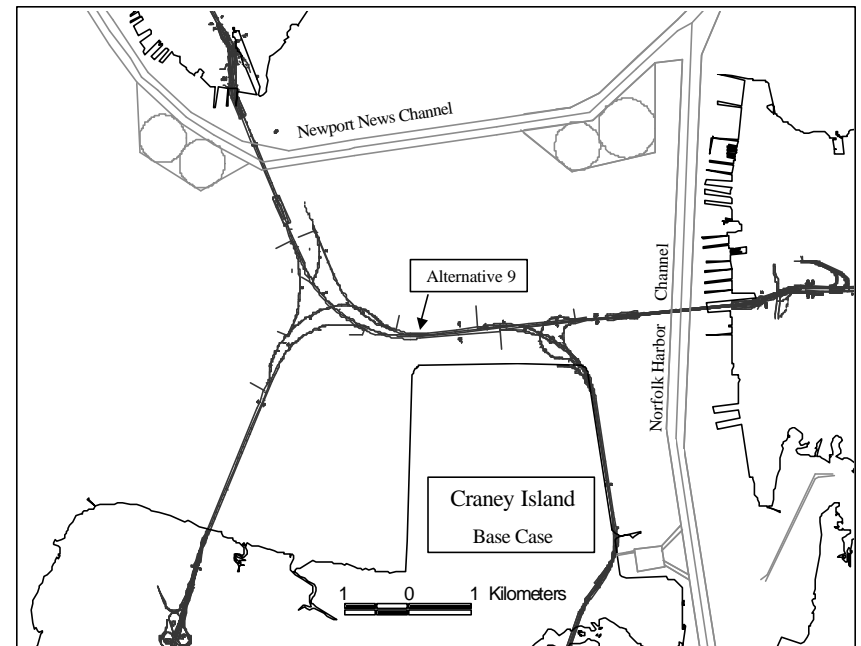
# Global Analysis

- Determine average differences of test case from base case cell-by-cell
- Plot these differences spatially
- Sort these differences on an areal basis
- Compare 95<sup>th</sup> Percentiles
  - values exceeded by only 5% of the total area

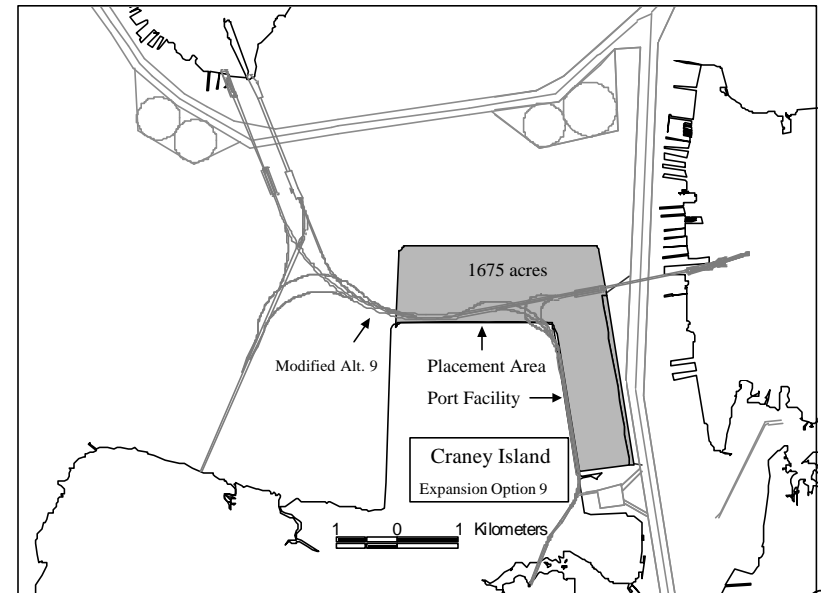
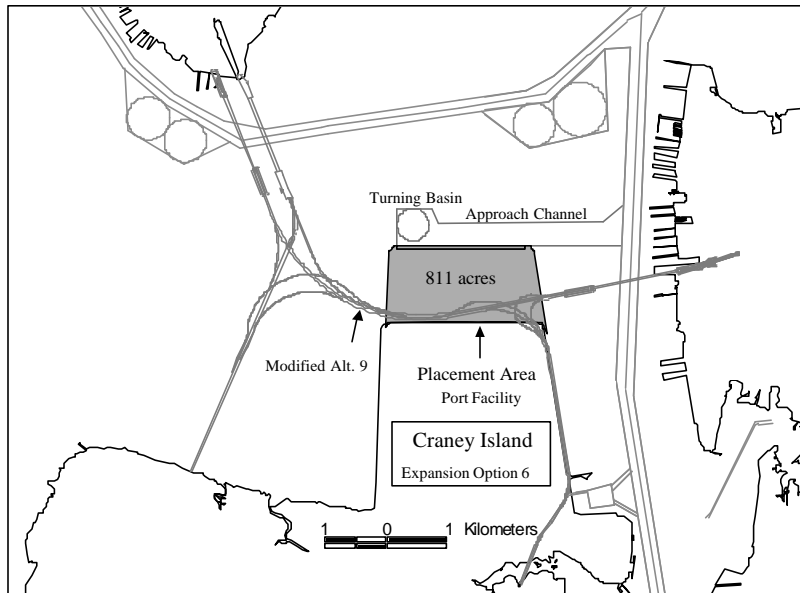
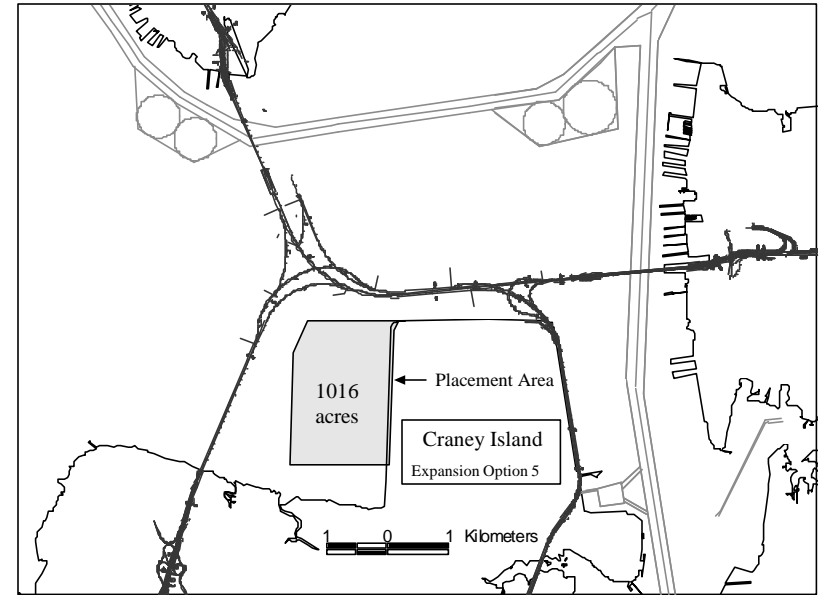
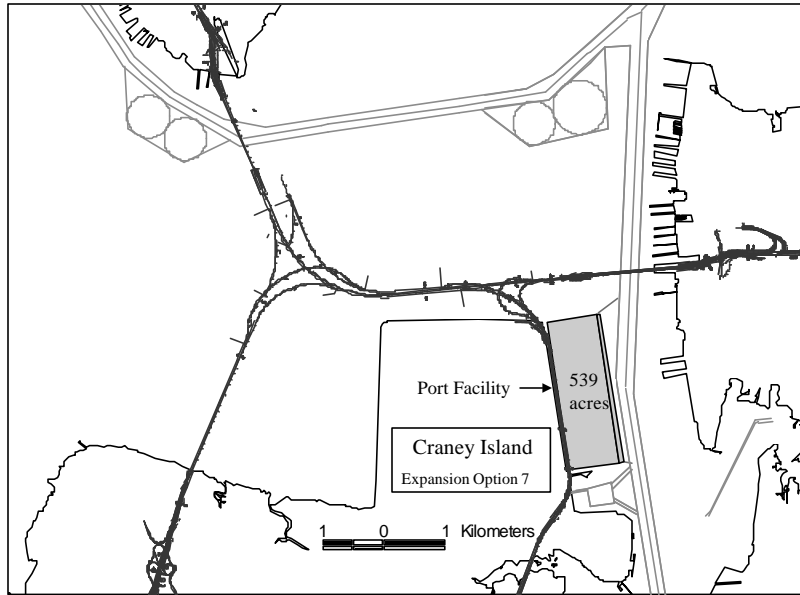


# Base Case

- Define “Base Case” to be the existing condition (e.g., I-64 and I-664) but also to include future VDOT Third Crossing
- Quantitatively assess impacts of all test cases by comparing each scenario run to the Base Case
- For consistency, the Base Case of the current study was exactly that of the original study

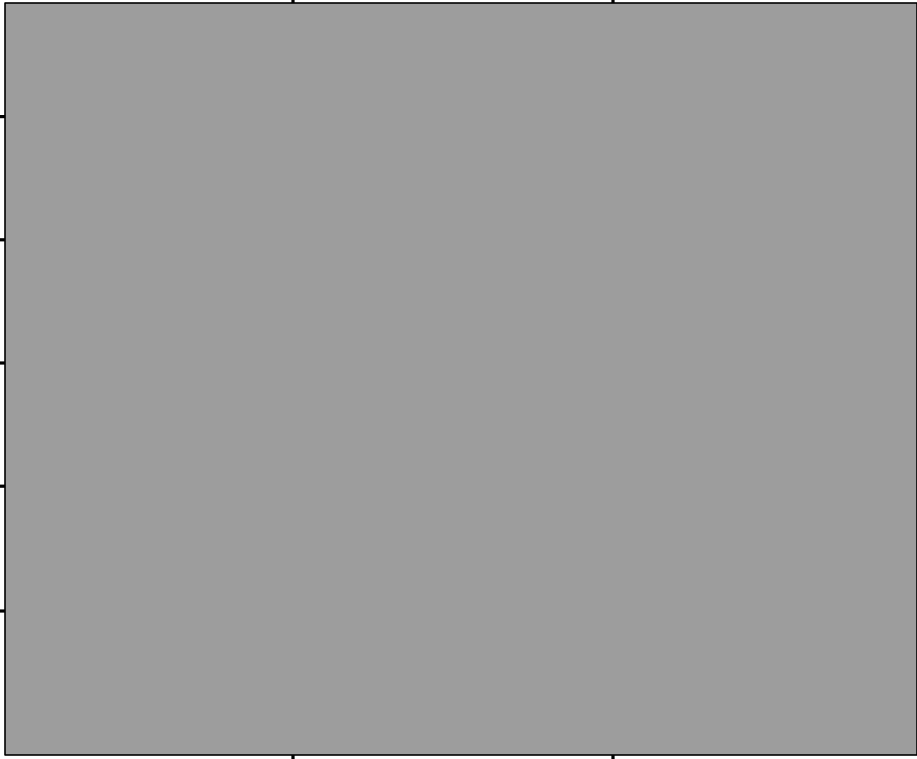


# Expansion Options Originally Modeled



# Global Change - 95<sup>th</sup> Percentile

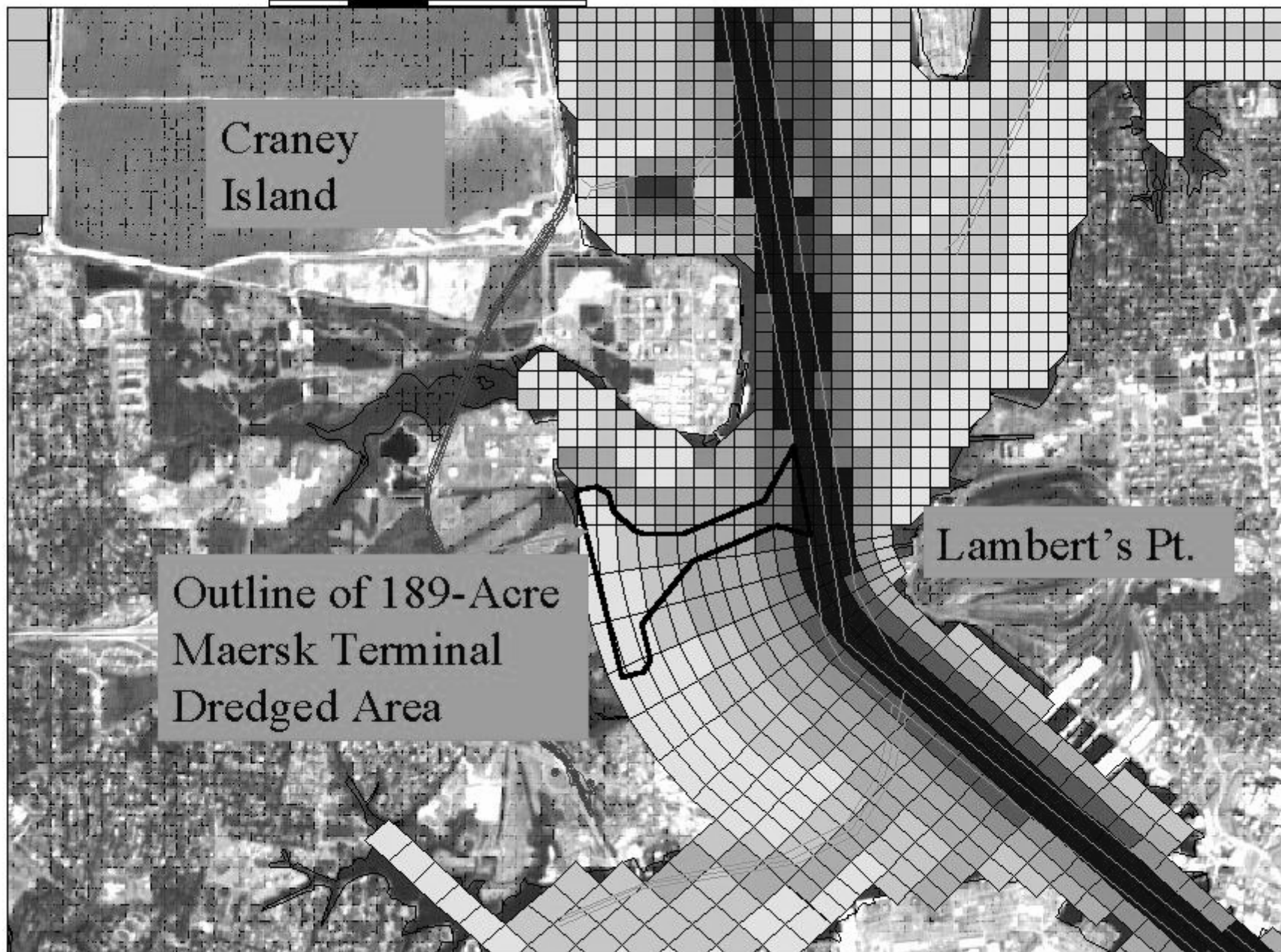
(5% of area contains change greater than value listed)

<b>Change in:</b>	<b>East 50' channel</b>	<b>West 50' channel</b>	<b>North 50' channel</b>	<b>N-East 50' channel</b>
<b>Surface Elev.</b>	0.14 cm			
<b>Surface Current</b>	2.4 cm/s			
<b>Bottom Current</b>	1.6 cm/s			
<b>Surface Salinity</b>	0.00 ppt			
<b>Bottom Salinity</b>	0.00 ppt			
<b>Sedimentation Potential</b>	0.08%			

# Outline

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1 0 1 Kilometers



# Setup of Model Run

## APM Terminal Site Dredging

- Site specifications:
  - dredging depth: 52 feet MLLW ( 16.2 m NGVD)
  - area: 189 acres ( 0.765 km<sup>2</sup>)
  - volume: 10.3 million yds<sup>3</sup> (7.875 million m<sup>3</sup>)
- Model consistency check:
  - dredging depth: 16.2 m NGVD (as specified)
  - area: 0.747 km<sup>2</sup> (within 2.4%)
  - volume: 7.837 million m<sup>3</sup> (within 0.5%)

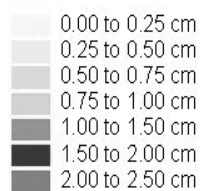


# Spatial Plots (APM dredging impact)

- Surface Elevation RMS difference
- Salinity Avg. Difference (surface & bottom)
- Velocity Magnitude RMS (surf. & bottom)
- Residual Vel. Mag. Avg. Diff. (surf & bot)
- Sedimentation Potential Difference

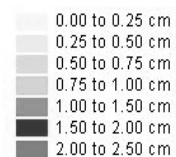
Surface Elevation  
RMS difference  
CIEE vs. Base Case

RMS difference



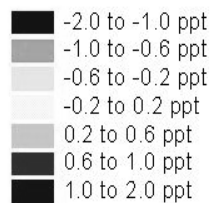
Surface Elevation  
RMS difference  
CIEE+APM vs. Base Case

RMS difference



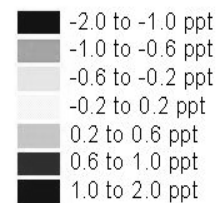
Surface Salinity  
Average Difference  
CIEE vs. Base Case

Average difference

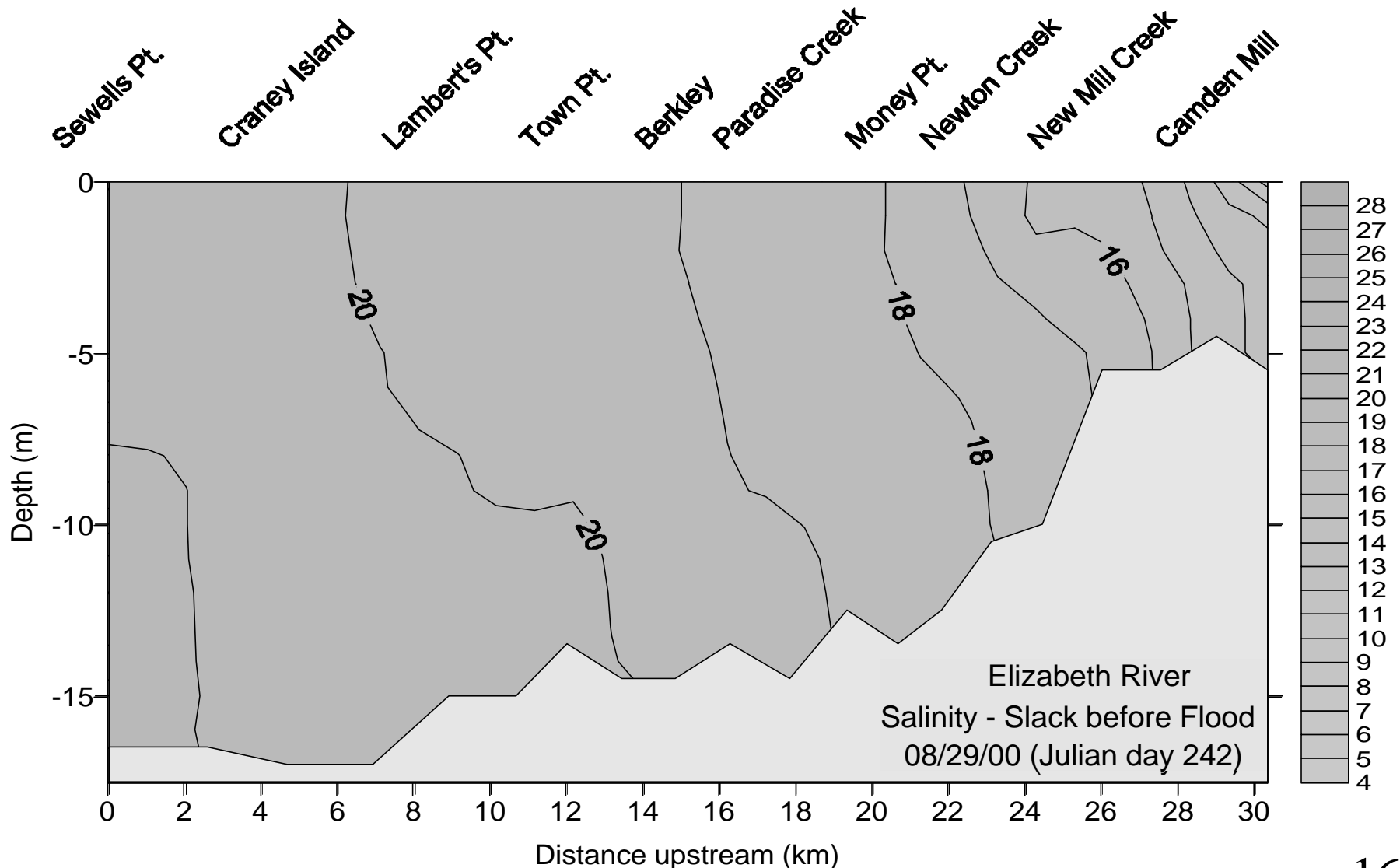


Surface Salinity  
Average Difference  
CIEE+APM vs. Base Case

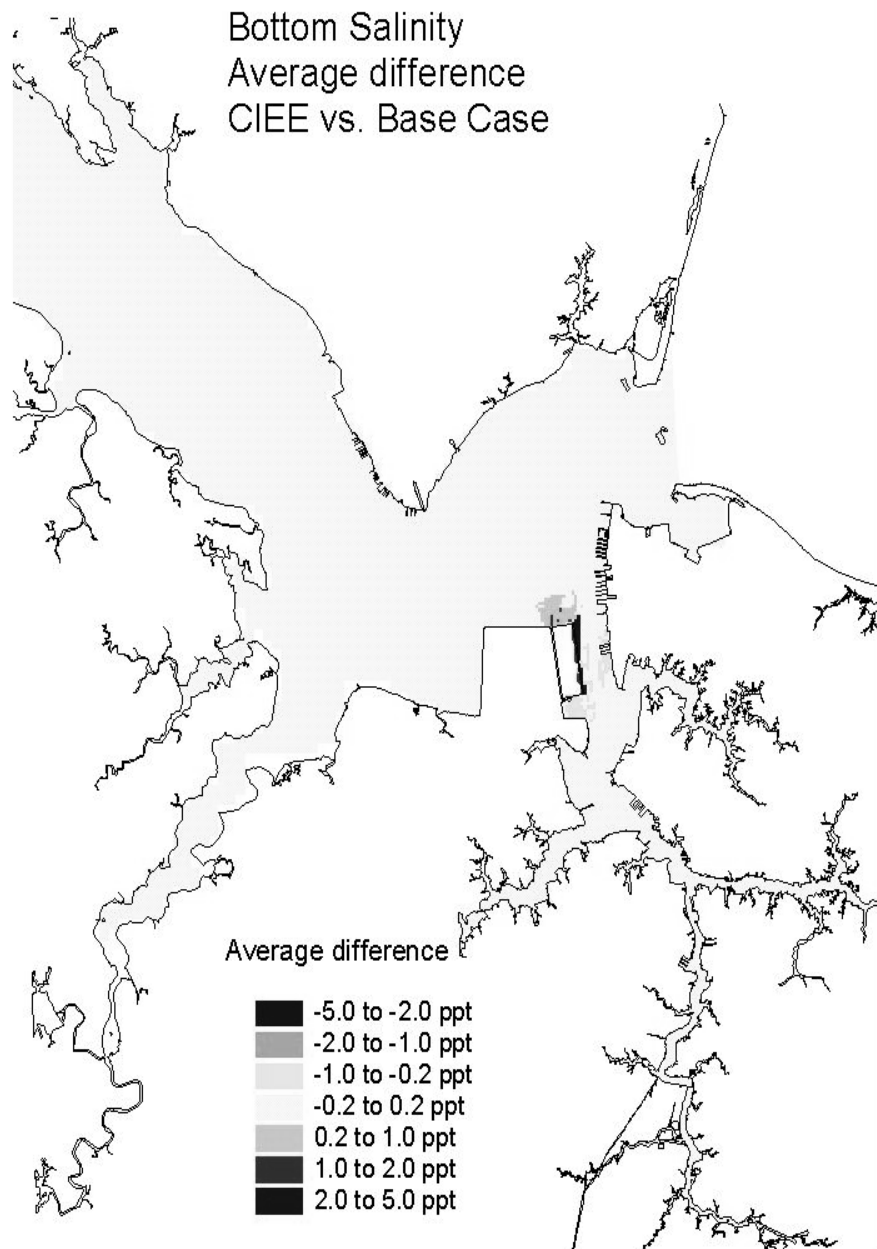
Average difference



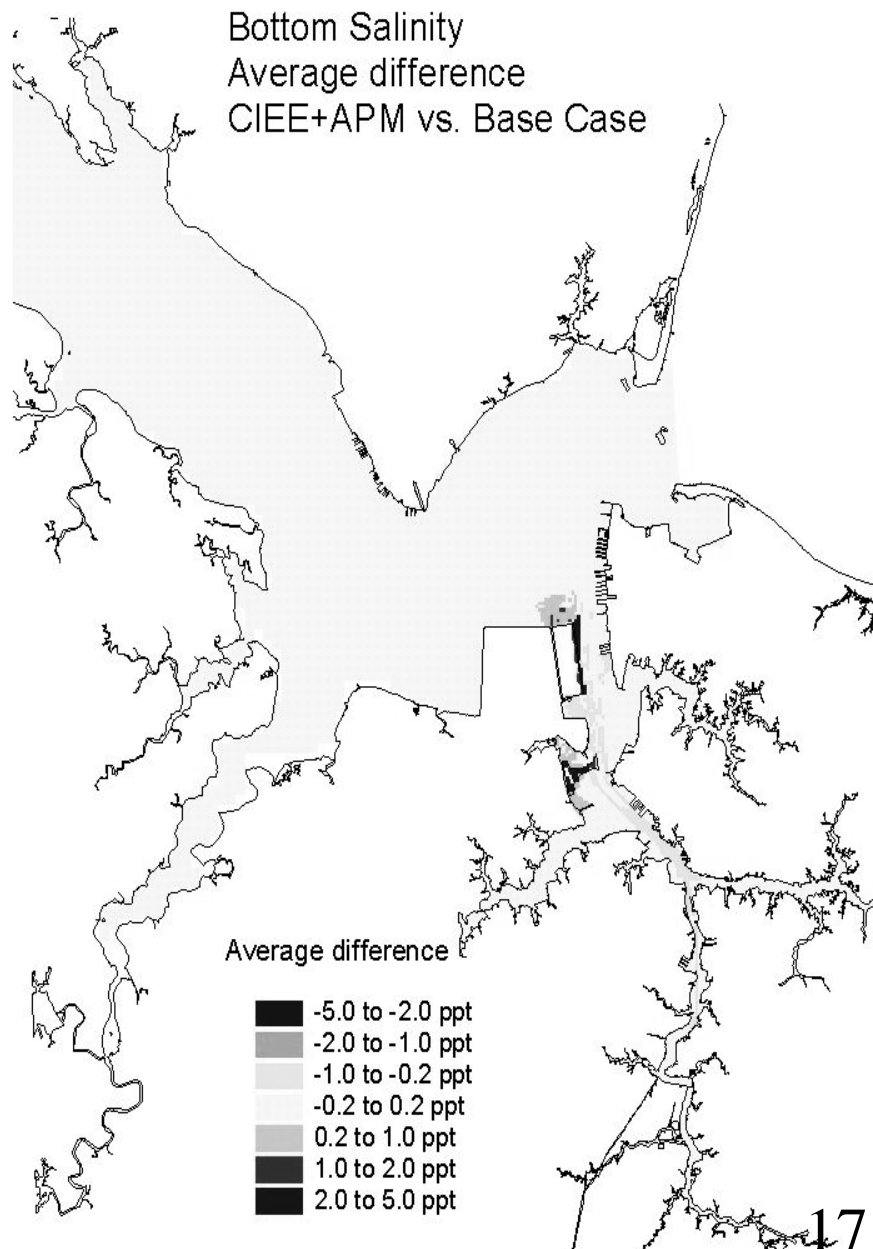
# Elizabeth River Salinity – Natural Variability



Bottom Salinity  
Average difference  
CIEE vs. Base Case

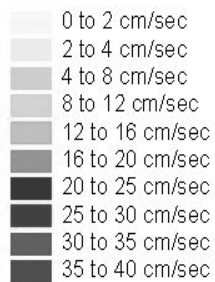


Bottom Salinity  
Average difference  
CIEE+APM vs. Base Case



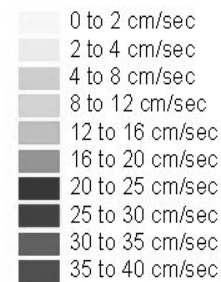
Surface Velocity  
Magnitude  
RMS difference  
CIEE vs. Base Case

RMS difference



Surface Velocity  
Magnitude  
RMS difference  
CIEE+APM vs. Base Case

RMS difference



Bottom Velocity  
Magnitude  
RMS difference  
CIEE vs. Base Case

RMS difference

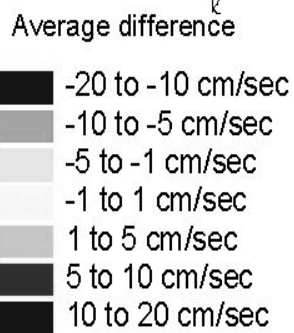
0 to 2 cm/sec
2 to 4 cm/sec
4 to 8 cm/sec
8 to 12 cm/sec
12 to 16 cm/sec
16 to 20 cm/sec
20 to 25 cm/sec
25 to 30 cm/sec

Bottom Velocity  
Magnitude  
RMS difference  
CIEE+APM vs. Base Case

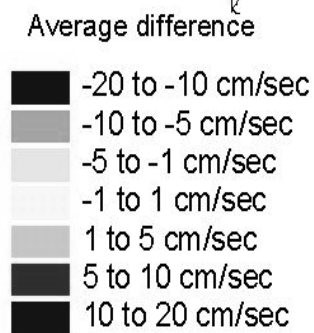
RMS difference

0 to 2 cm/sec
2 to 4 cm/sec
4 to 8 cm/sec
8 to 12 cm/sec
12 to 16 cm/sec
16 to 20 cm/sec
20 to 25 cm/sec
25 to 30 cm/sec

Surface Residual  
Velocity Magnitude  
Average Difference  
CIEE vs. Base Case

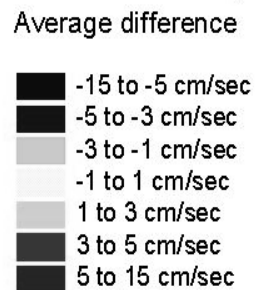


Surface Residual  
Velocity Magnitude  
Average difference  
CIEE+APM vs. Base Case

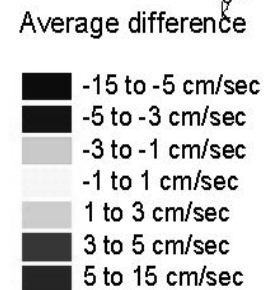




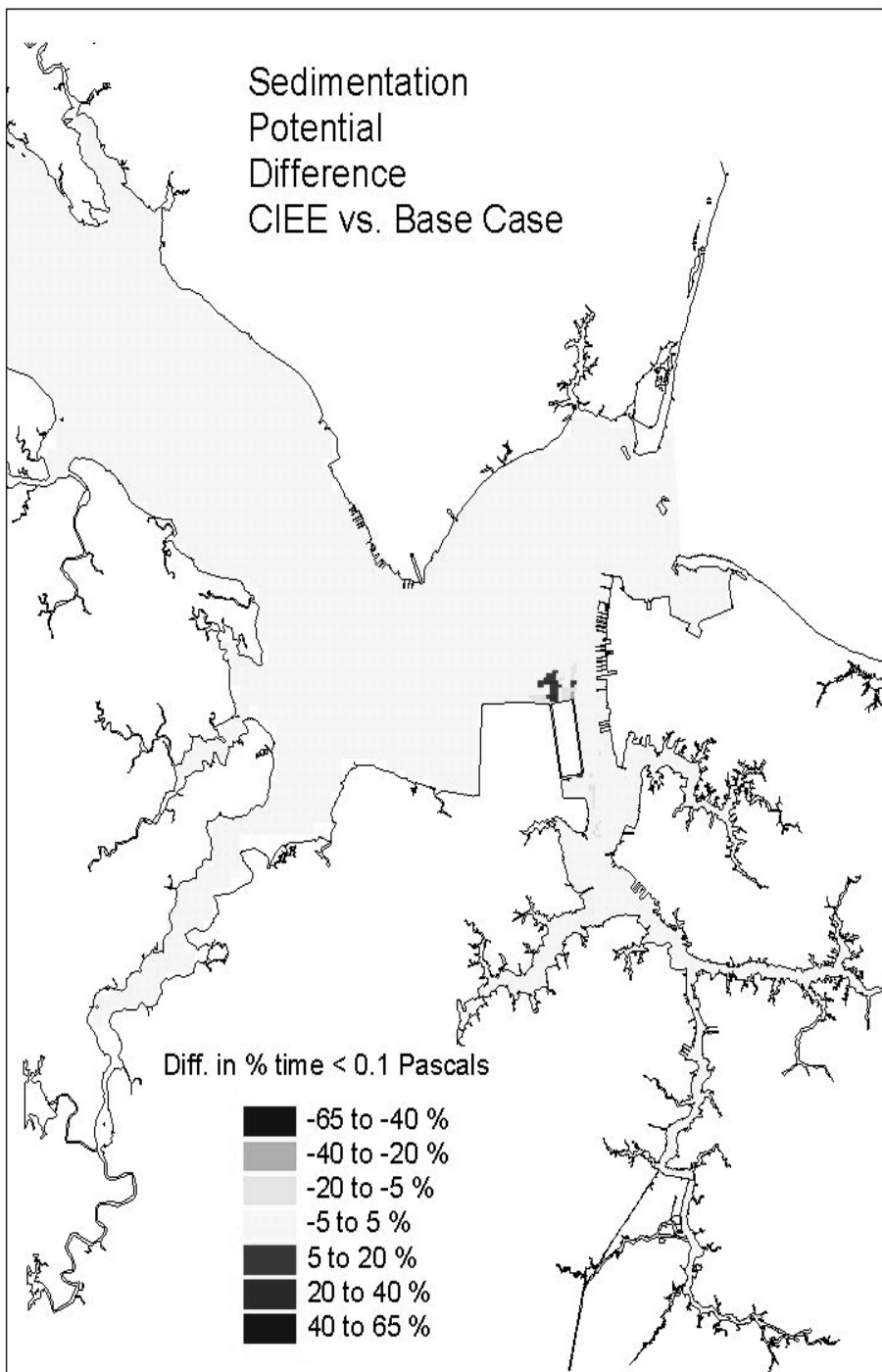
Bottom Residual  
Velocity Magnitude  
Average Difference  
CIEE vs. Base Case



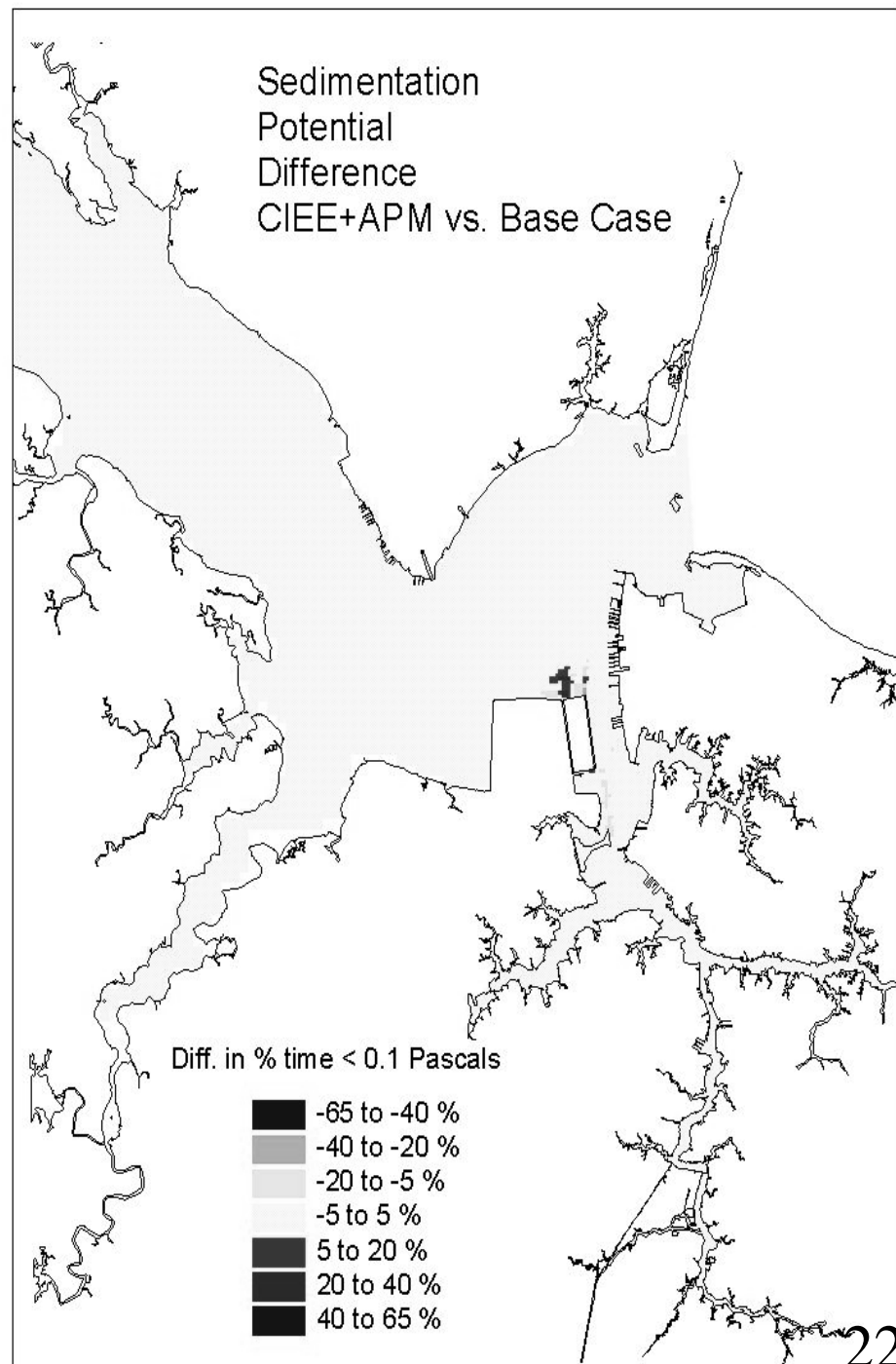
Bottom Residual  
Velocity Magnitude  
Average difference  
CIEE+APM vs. Base Case



Sedimentation  
Potential  
Difference  
CIEE vs. Base Case



Sedimentation  
Potential  
Difference  
CIEE+APM vs. Base Case

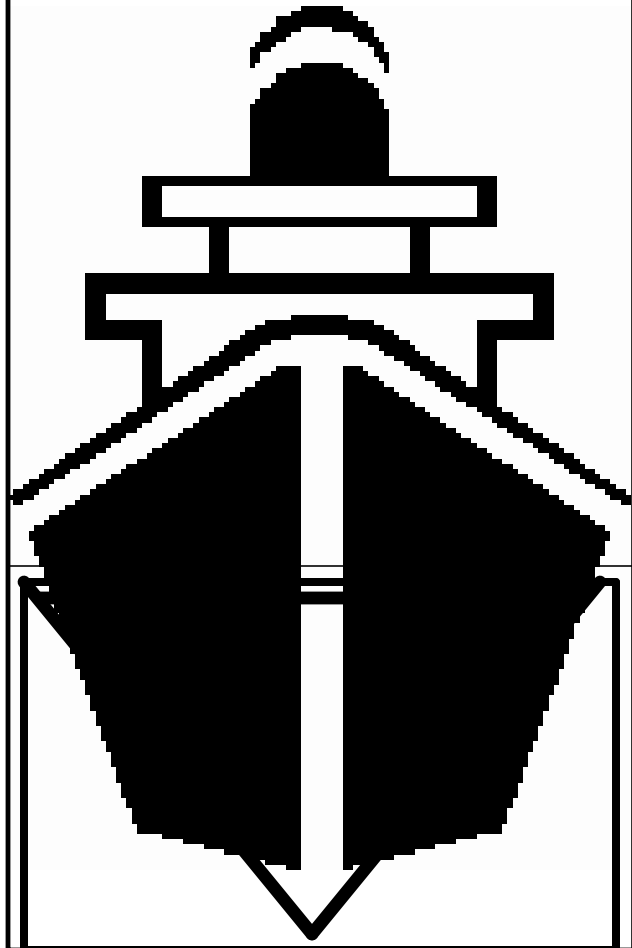


# Outline

- Review of prior CIEE study and results
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**Front view**

## **Ships Modeled Using Frictional Parameterization**



← 47-foot draft

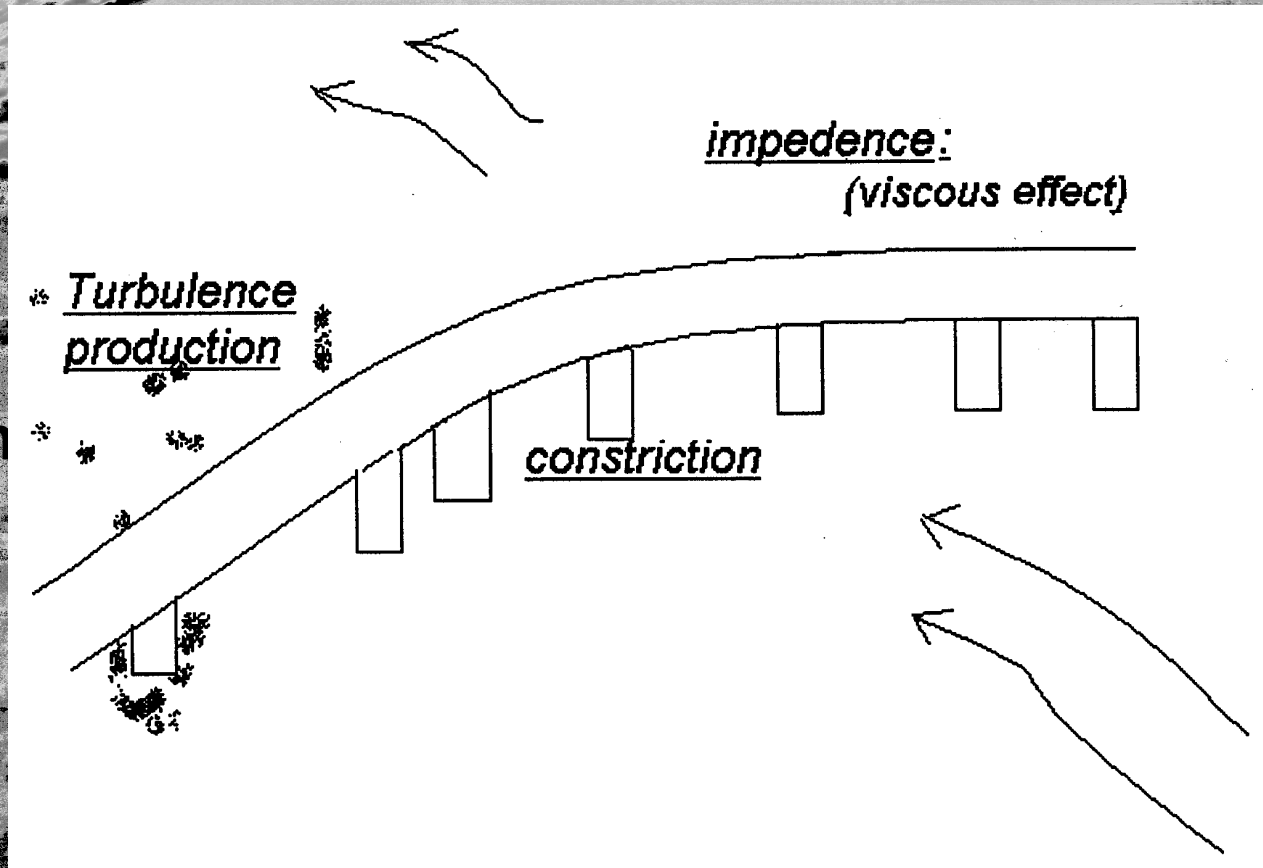
← 53-foot depth MLLW

← ship beam 140 feet →

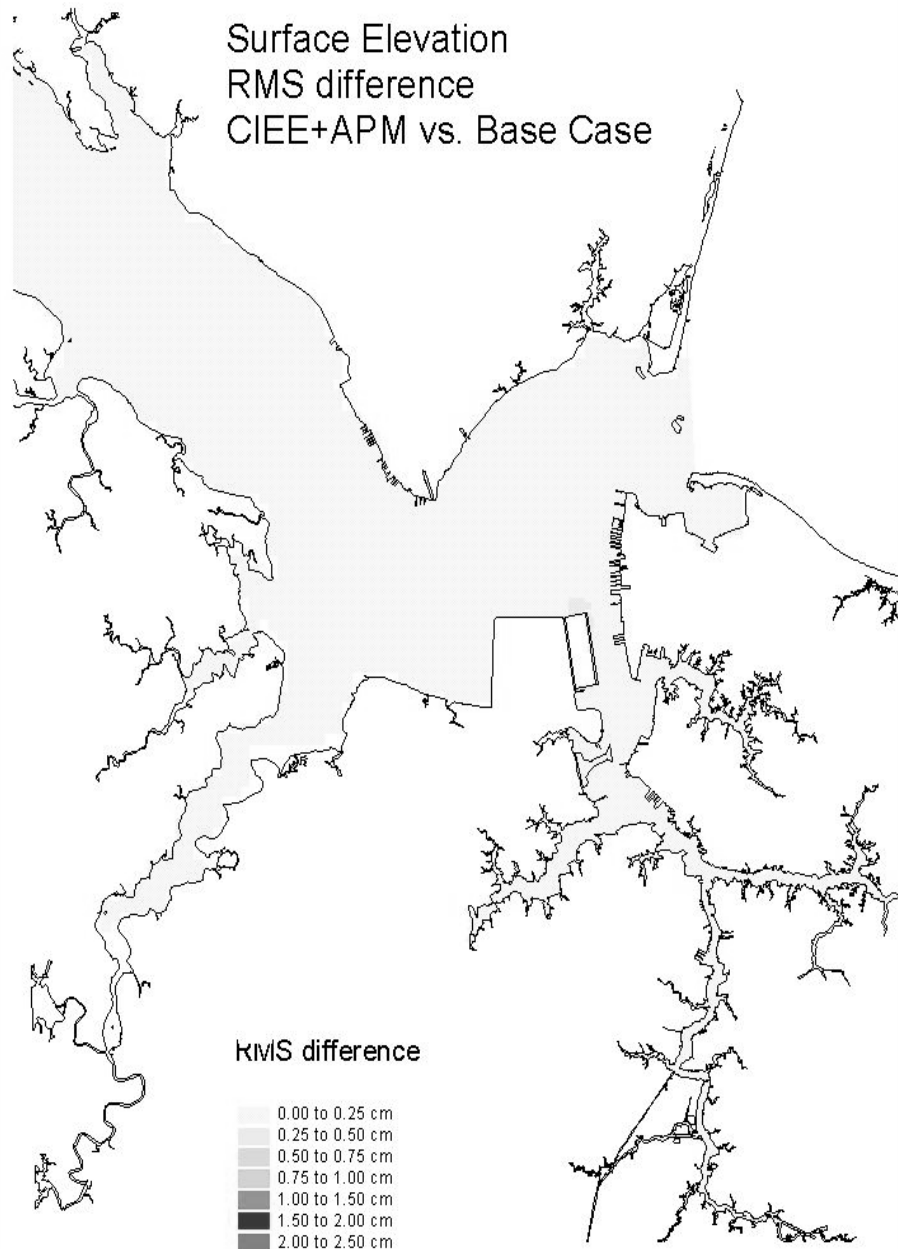
← model cell width 405 feet →

I-64

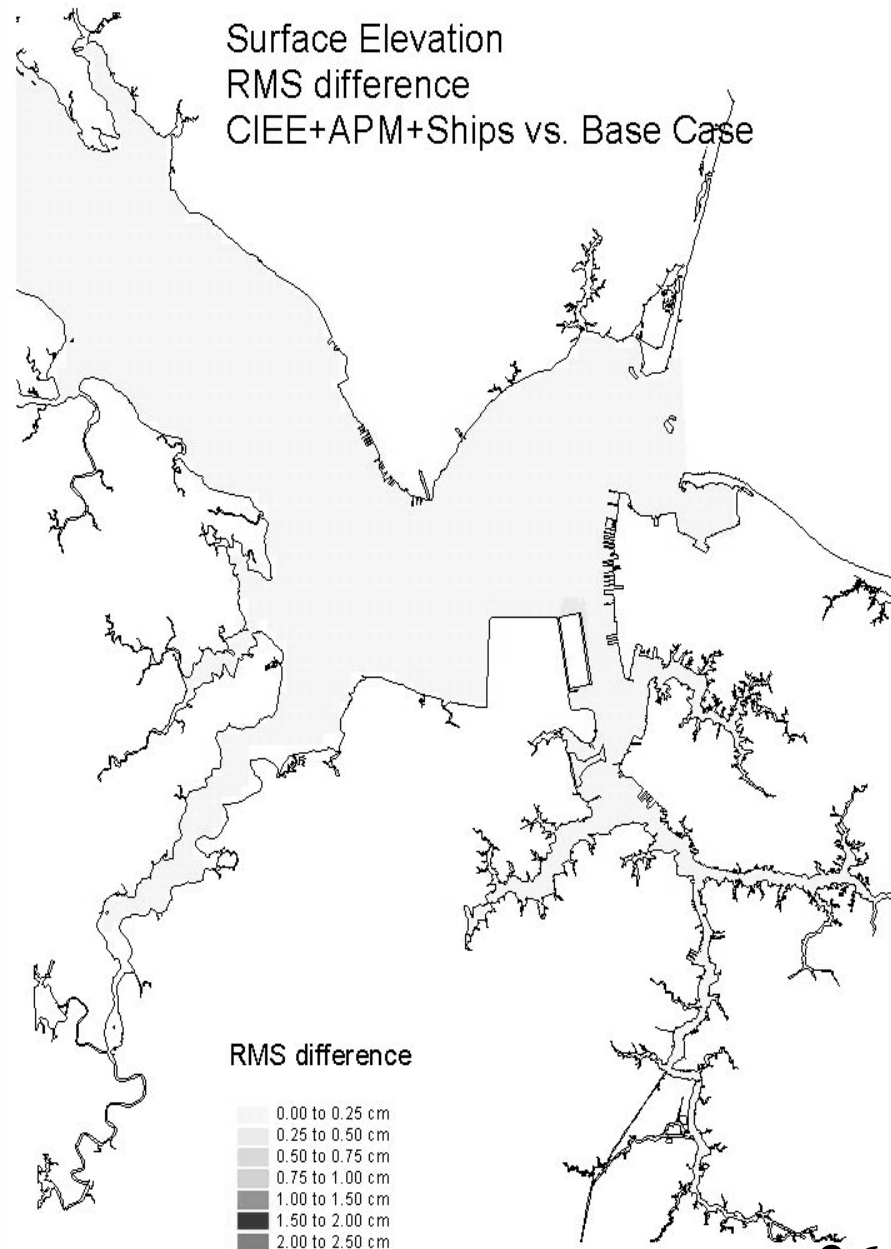
Willoughby



Surface Elevation  
RMS difference  
CIEE+APM vs. Base Case

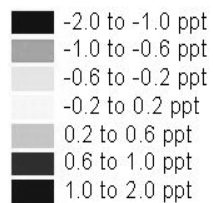


Surface Elevation  
RMS difference  
CIEE+APM+Ships vs. Base Case



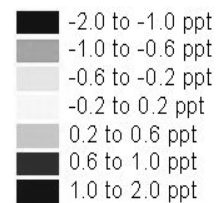
Surface Salinity  
Average Difference  
CIEE+APM vs. Base Case

Average difference

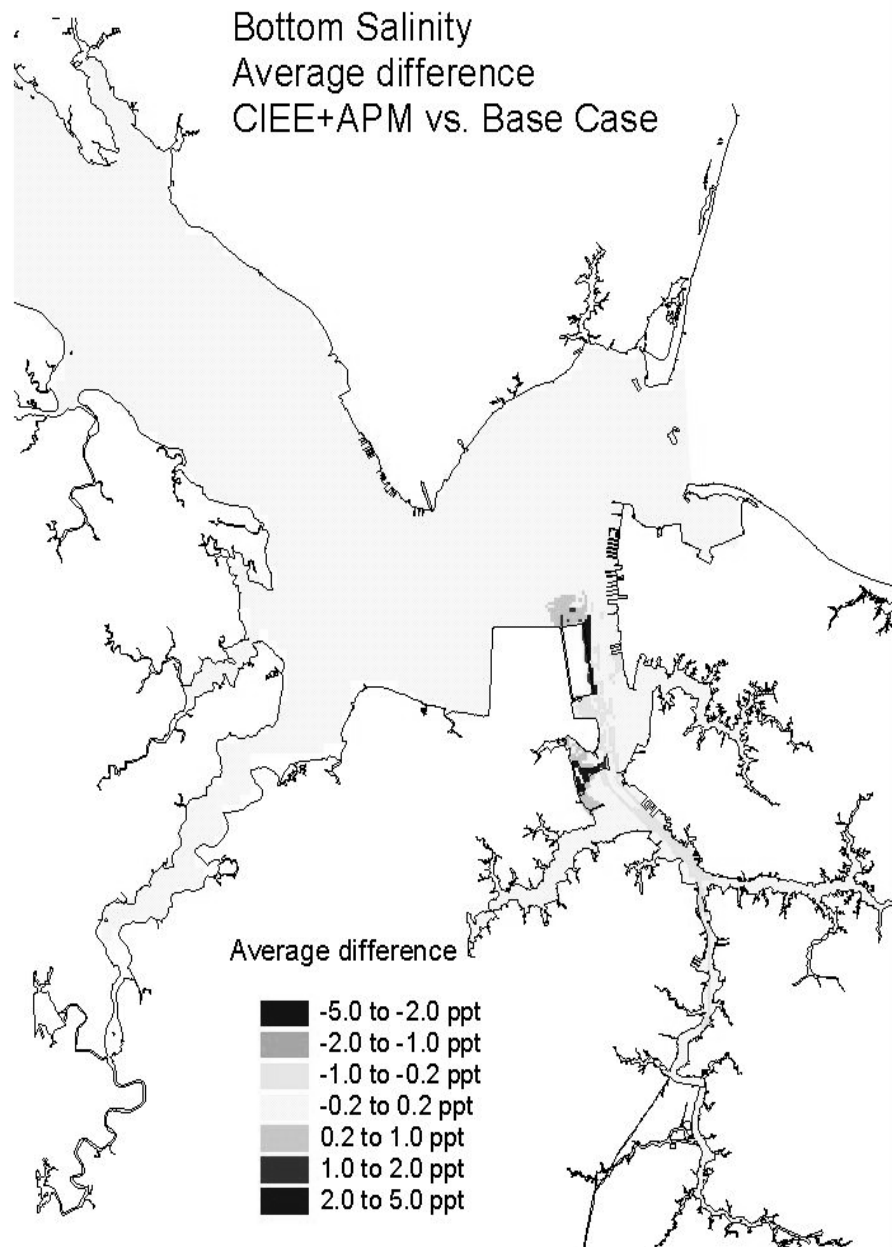


Surface Salinity  
Average Difference  
CIEE+APM+Ships vs. Base Case

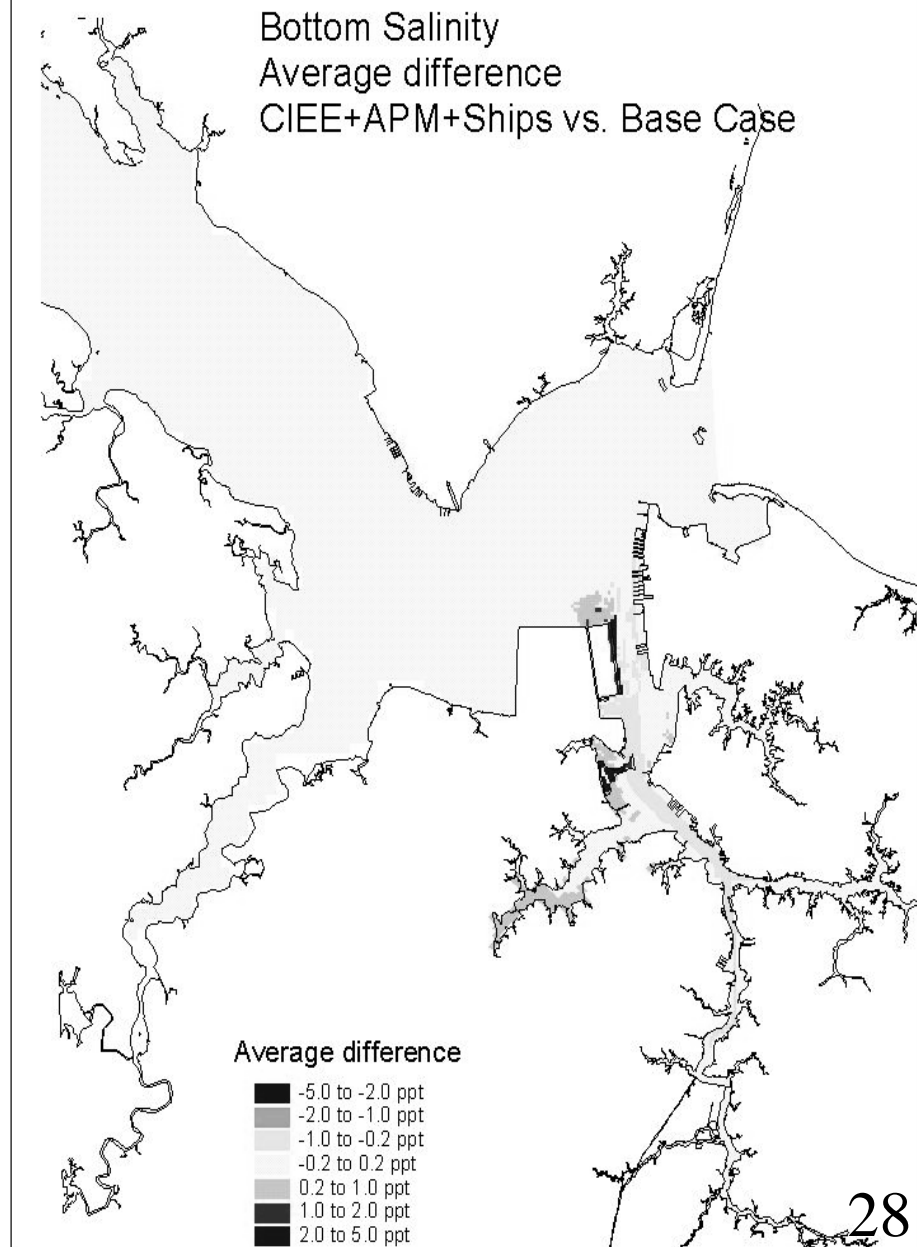
Average difference



Bottom Salinity  
Average difference  
CIEE+APM vs. Base Case



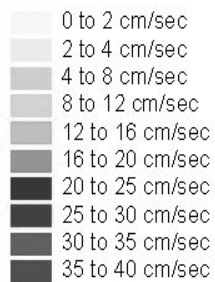
Bottom Salinity  
Average difference  
CIEE+APM+Ships vs. Base Case





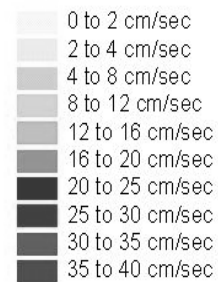
Surface Velocity  
Magnitude  
RMS difference  
CIEE+APM vs. Base Case

RMS difference



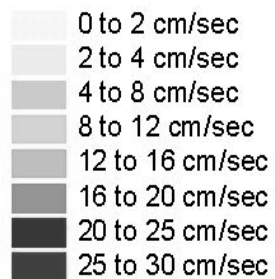
Surface Velocity  
Magnitude  
RMS difference  
CIEE+APM+Ships vs. Base Case

RMS difference



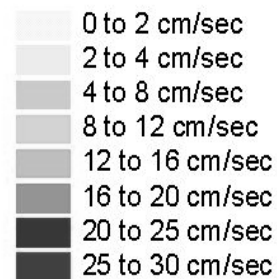
Bottom Velocity  
Magnitude  
RMS difference  
CIEE+APM vs. Base Case

RMS difference

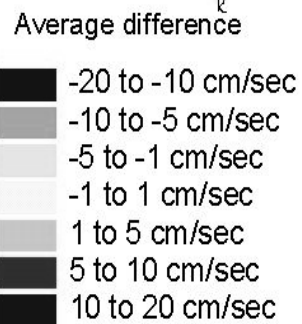


Bottom Velocity  
Magnitude  
RMS difference  
CIEE+APM+Ships vs. Base Case

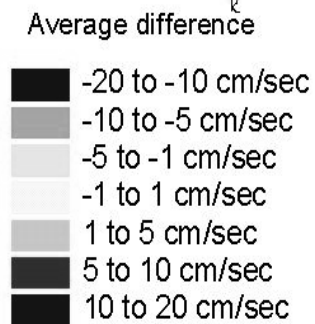
RMS difference



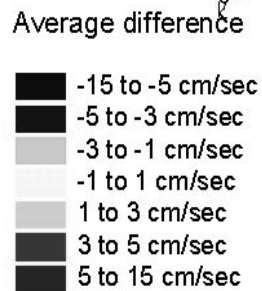
Surface Residual  
Velocity Magnitude  
Average difference  
CIEE+APM vs. Base Case



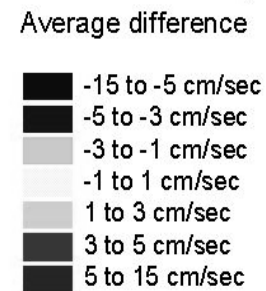
Surface Residual  
Velocity Magnitude  
Average difference  
CIEE+APM+Ships vs. Base Case



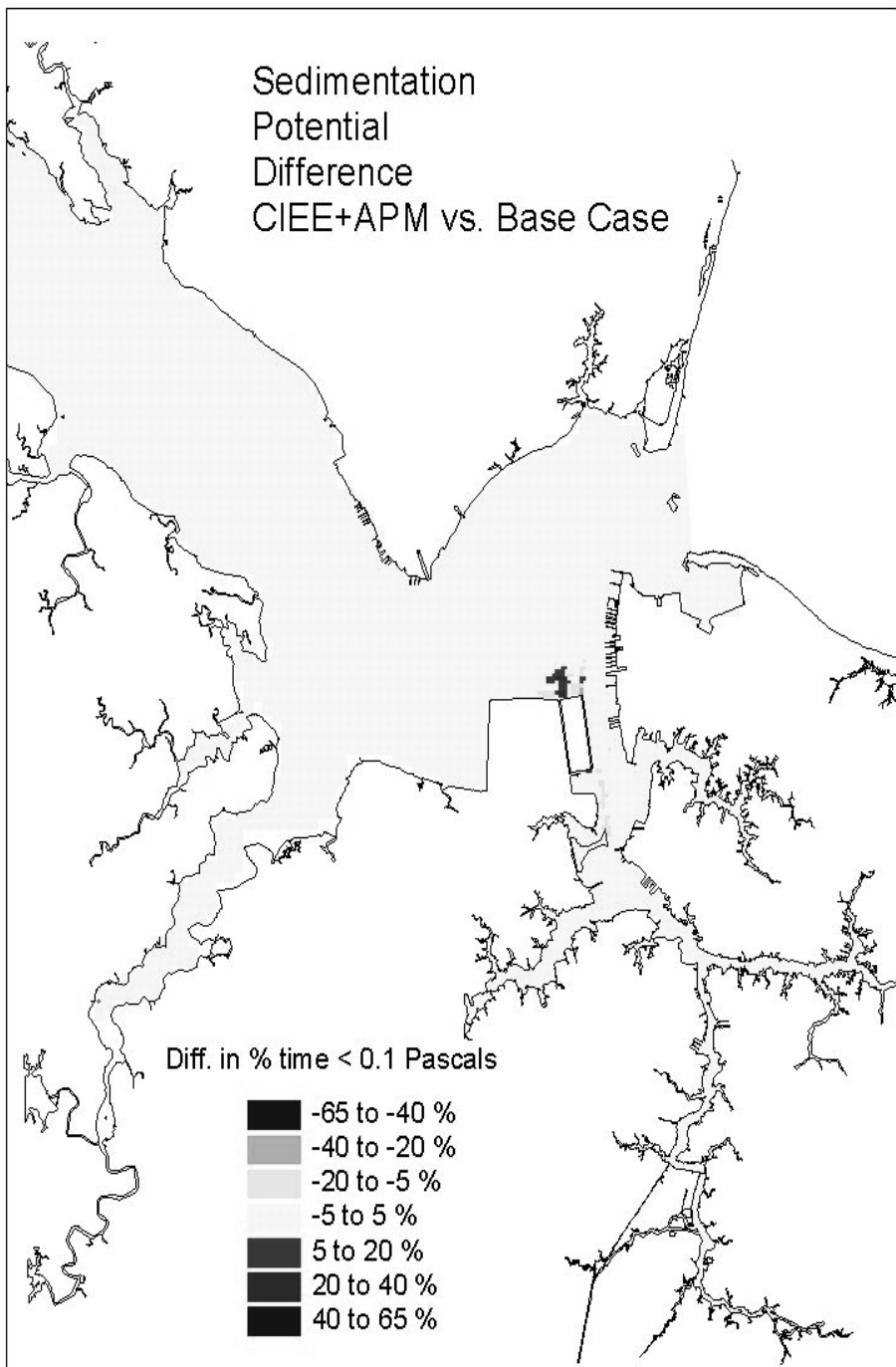
Bottom Residual  
Velocity Magnitude  
Average difference  
CIEE+APM vs. Base Case



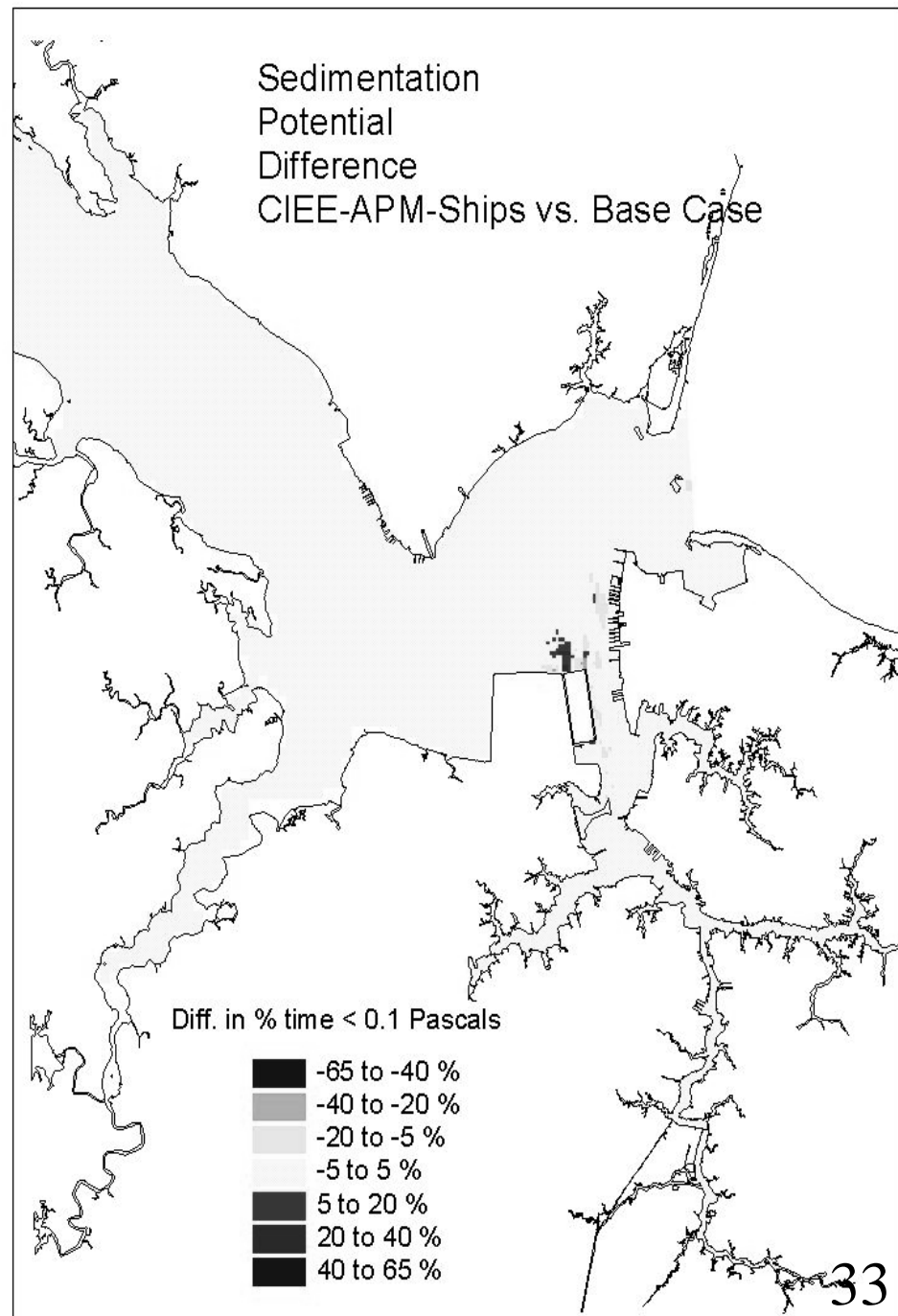
Bottom Residual  
Velocity Magnitude  
Average difference  
CIEE+APM+Ships vs. Base Case



Sedimentation  
Potential  
Difference  
CIEE+APM vs. Base Case



Sedimentation  
Potential  
Difference  
CIEE-APM-Ships vs. Base Case



# Global Change - 95<sup>th</sup> Percentile

(5% of area contains change greater than value listed)

<b>Change in:</b>	CIEE only	CIEE + APM dredging	CIEE +APM dredging + triangular ships	CIEE +APM dredging + square ships
<b>Surface Elev.</b>	0.14 cm	0.13 cm	0.13 cm	0.14 cm
<b>Surface Current</b>	2.4 cm/s	2.4 cm/s	2.5 cm/s	2.6 cm/s
<b>Bottom Current</b>	1.6 cm/s	1.7 cm/s	2.1 cm/s	2.5 cm/s
<b>Surface Salinity</b>	0.00 ppt	0.10 ppt	0.15 ppt	0.19 ppt
<b>Bottom Salinity</b>	0.00 ppt	0.06 ppt	0.10 ppt	0.15 ppt
<b>Sedimentation Potential</b>	0.08%	0.08%	0.09%	0.10%

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# Global Change - 95<sup>th</sup> Percentile

(5% of area contains change greater than value listed)

## Single Variable - 50' Channel Cases

<b>Change in:</b>	<b>Eastward</b>	<b>Eastward + dredging + ships</b>	<b>Westward</b>	<b>Northward</b>	<b>Northeastward</b>
<b>Surface Elevation</b>	0.14 cm	0.14 cm	0.34 cm	1.00 cm	1.04 cm
<b>Surface Current</b>	2.4 cm/s	2.6 cm/s	5.3 cm/s	12.3 cm/s	11.7 cm/s
<b>Bottom Current</b>	1.6 cm/s	2.5 cm/s	3.3 cm/s	7.8 cm/s	6.6 cm/s
<b>Surface Salinity</b>	0.00 ppt	0.19 ppt	0.12 ppt	0.71 ppt	0.23 ppt
<b>Bottom Salinity</b>	0.00 ppt	0.15 ppt	0.35 ppt	1.00 ppt	0.23 ppt
<b>Sedimentation Potential</b>	0.08 %	0.10 %	2.8 %	8.9 %	6.3 %



# Global Change – 95<sup>th</sup> Percentile

(5% of area contains change greater than value listed)

## Historical – High Discharge Event

<b>Change in:</b>	<b>Eastward 50'</b>	<b>Eastward + Dredging + Ships</b>	<b>Eastward-Westward 50'</b>
<b>Surface Elevation</b>	0.20 cm	0.20 cm	0.33 cm
<b>Surface Current</b>	5.5 cm/s	5.9 cm/s	6.7 cm/s
<b>Bottom Current</b>	2.7 cm/s	3.6 cm/s	3.7 cm/s
<b>Surface Salinity</b>	0.00 ppt	0.08 ppt	0.02 ppt
<b>Bottom Salinity</b>	0.00 ppt	0.09 ppt	0.07 ppt
<b>Sedimentation Potential</b>	1.0 %	1.1 %	1.9 %

# Global Change – 95<sup>th</sup> Percentile

(5% of area contains change greater than value listed)

## Historical – Low Discharge Event

<b>Change in:</b>	<b>Eastward 50'</b>	<b>Eastward + Dredging + Ships</b>	<b>Eastward-Westward 50'</b>
<b>Surface Elevation</b>	0.14 cm	0.14 cm	0.33 cm
<b>Surface Current</b>	2.7 cm/s	3.0 cm/s	4.3 cm/s
<b>Bottom Current</b>	1.9 cm/s	2.7 cm/s	2.9 cm/s
<b>Surface Salinity</b>	0.00 ppt	0.12 ppt	0.04 ppt
<b>Bottom Salinity</b>	0.01 ppt	0.16 ppt	0.09 ppt
<b>Sedimentation Potential</b>	0.9 %	1.0 %	2.8 %

# Global Change – 95<sup>th</sup> Percentile

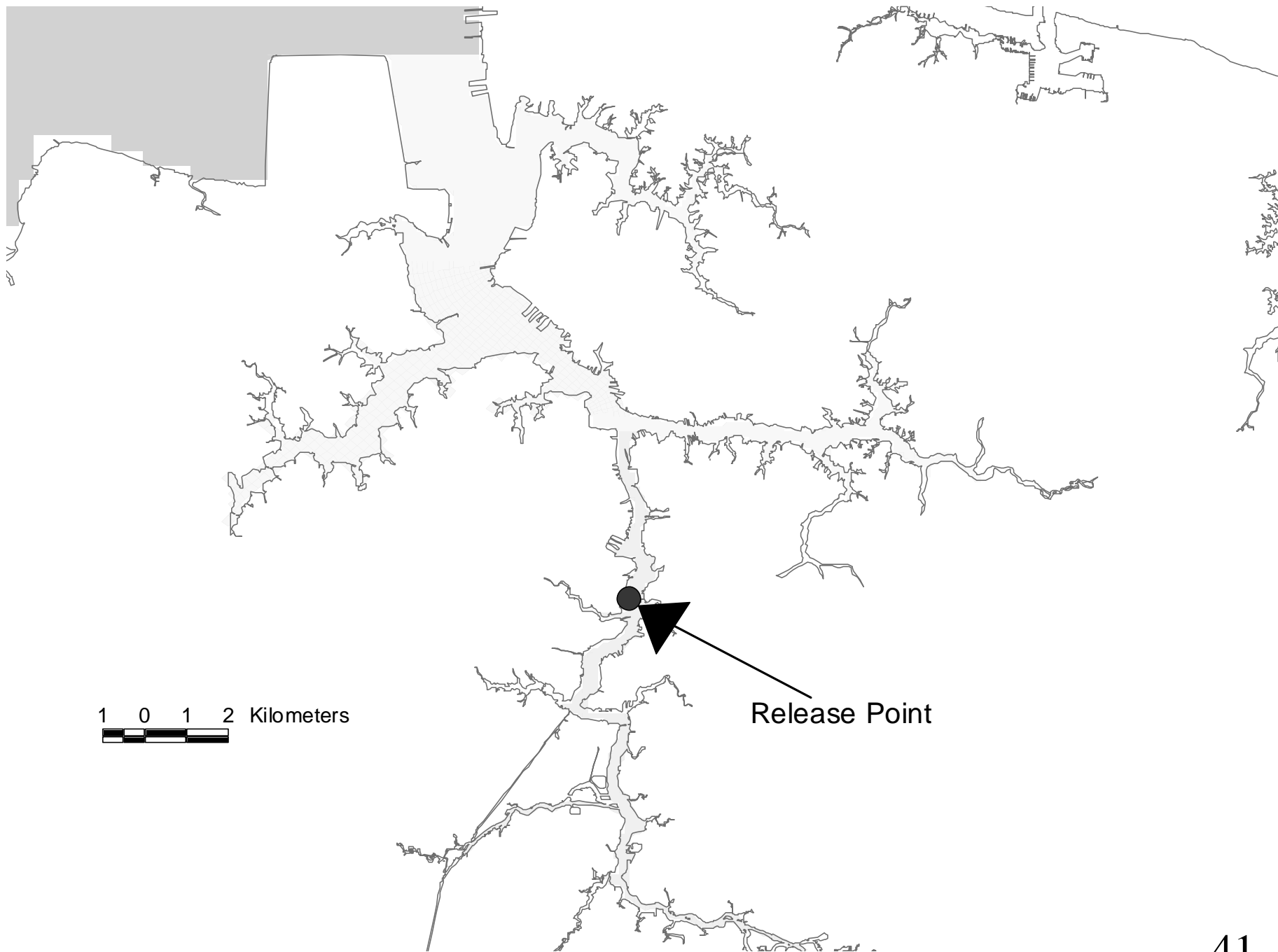
(5% of area contains change greater than value listed)

## Historical – High Wind Event

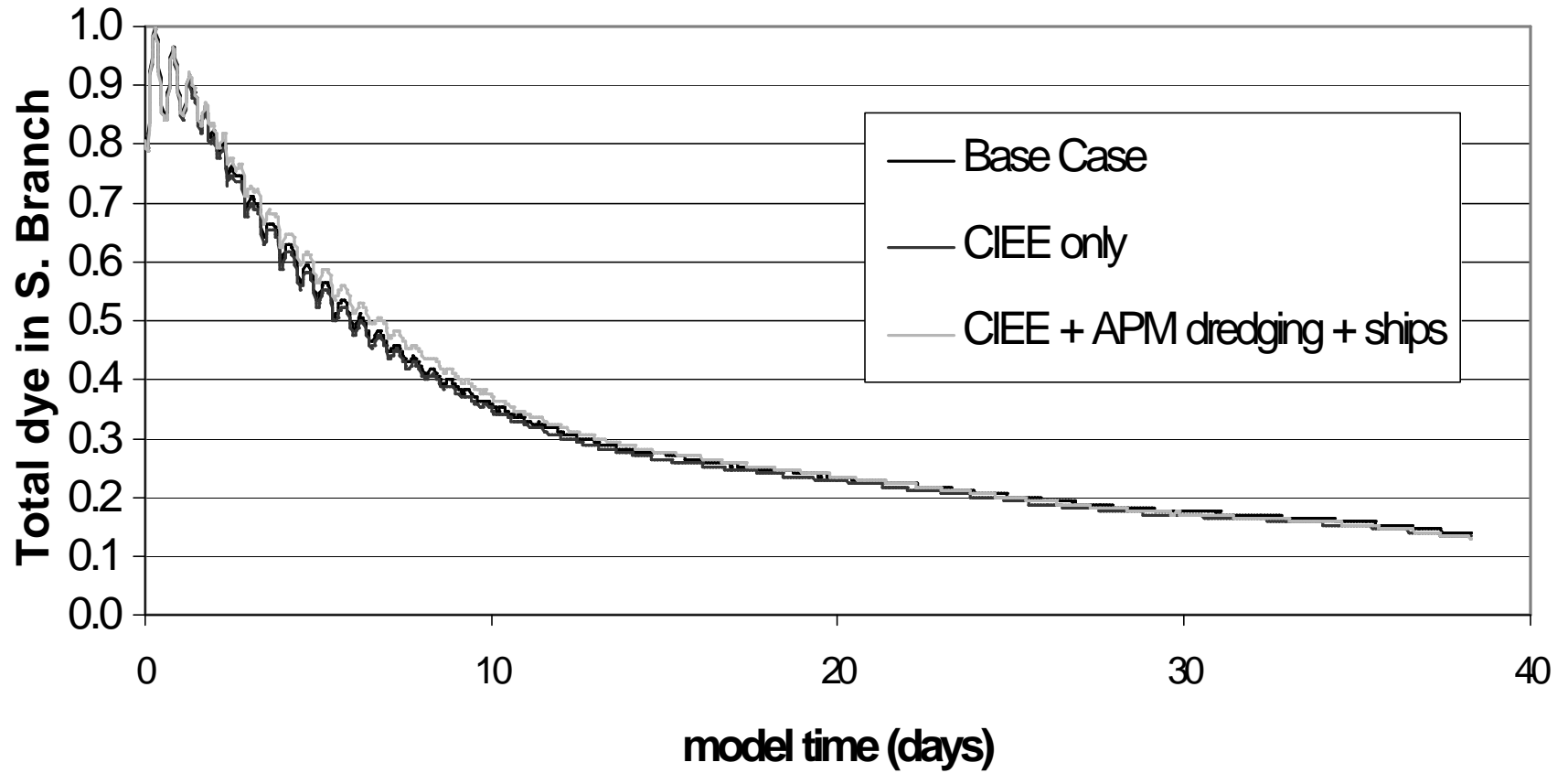
<b>Change in:</b>	<b>Eastward 50'</b>	<b>Eastward + Dredging + Ships</b>	<b>Eastward-Westward 50'</b>
<b>Surface Elevation</b>	0.21 cm	0.21 cm	0.46 cm
<b>Surface Current</b>	2.2 cm/s	2.8 cm/s	5.0 cm/s
<b>Bottom Current</b>	1.5 cm/s	2.4 cm/s	3.0 cm/s
<b>Surface Salinity</b>	0.00 ppt	0.09 ppt	0.00 ppt
<b>Bottom Salinity</b>	0.00 ppt	0.11 ppt	0.02 ppt
<b>Sedimentation Potential</b>	0.8 %	0.9 %	1.7 %

# Outline

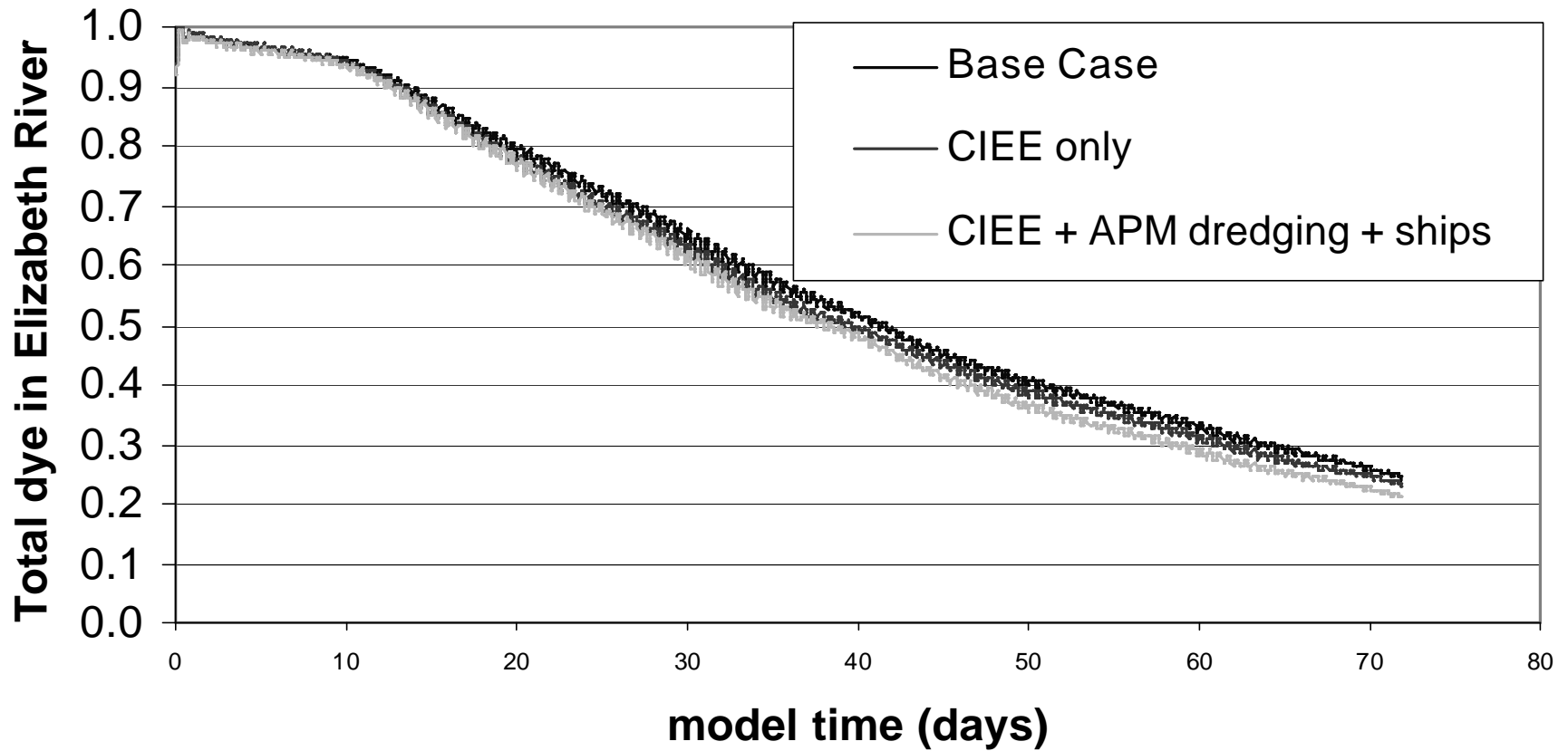
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## Dye Release Simulation - Southern Branch



## Dye Release Simulation - Elizabeth River



# Conclusions

- With the APM terminal site located in a low energy region, dredging and ship berthing both have a relatively small impact.
- Both APM terminal dredging and the berthing of ships have minimal impact on either surface elevation or sedimentation potential.
- Berthing of ships at CIEE, if considered permanent, has a localized effect on the salinity distribution, and to a lesser extent, the velocity distribution.



# Conclusions (con't.)

- Cumulative far-field impacts resulting from both dredging and ship berthing occurred on velocity and salinity distributions, but their magnitudes were less than those of the previously studied land expansions.
- The flushing of the Elizabeth River shows no detectable adverse response from the combined effects of the APM terminal dredging and ship berthing.